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(71) Applicant: **Turner, Donald E.**
Mobile, AL 36695 (US)

(72) Inventor: **Turner, Donald E.**
Mobile, AL 36695 (US)

(74) Representative: **Silverman, Warren et al**
Haseltine Lake & Co.
Imperial House,
15-19 Kingsway
London WC2B 6UD (GB)

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(54) Alternative refrigerant including hexafluoropropylene

(57) An alternative refrigerant to chlorofluorocarbons having the properties of being nontoxic, non-corrosive, nonflammable and safer to the environment including a blend of one or more of fluorocarbons known in the industry as R-1216 and R-22 and/or R-218 and one or more of the hydrocarbons identified as C1 through C6 on the carbon chain.

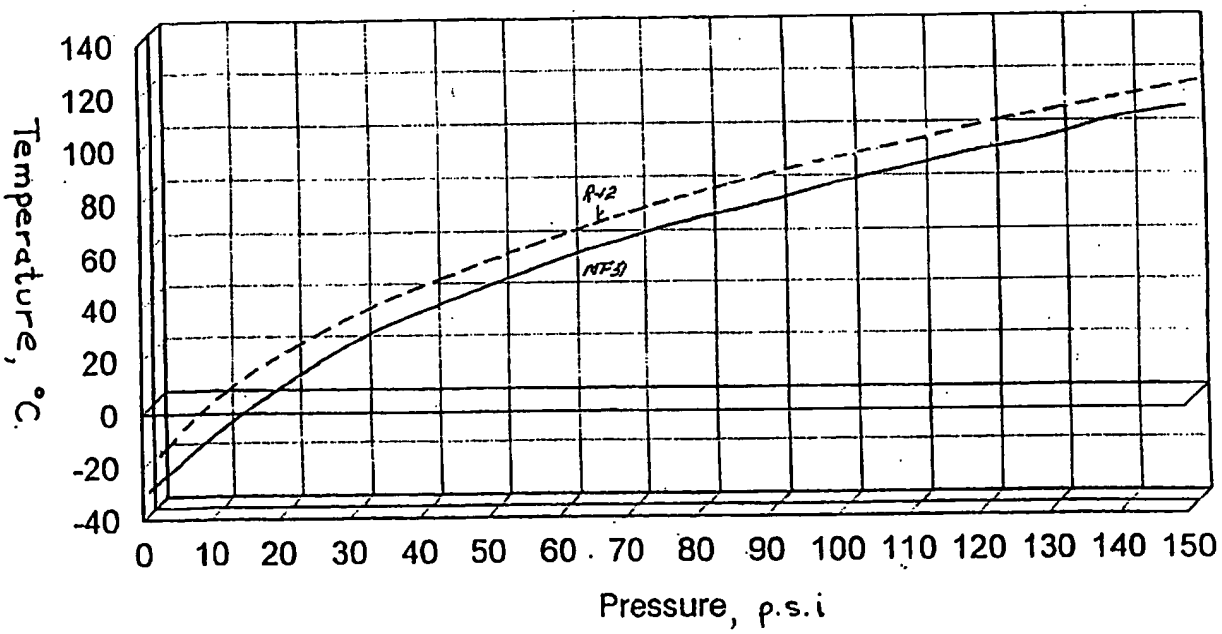

Fig. 1

EP 1 191 080 A2

tification or formulation of such blends is not predictable, particularly when cost, flammability and toxicity are primary concerns.

Summary of the Invention

[0009] The present invention is directed to a blend of fluorocarbons and hydrocarbons in an homogeneous manure which performs as a replacement refrigerant in systems designed for prior chlorofluorocarbons without retrofitting of the system, in a manner essentially according to the temperature/pressure curve of the replaced refrigerant.

[0010] The novel composition of the refrigerant of the present invention may be varied in the weight percentages of components to exhibit the various vapor pressure/temperature curves of other commercial refrigerants utilized in existing systems such that no retrofitting of the system is required.

[0011] While hydrocarbons are known to be flammable, the blend of particular hydrocarbons and/or certain fluorinated alkanes with particular selected halocarbons exhibits a near azeotropic character and the desirable nonflammability and nontoxicity with the added advantage of having a predictable and controllable vapor pressure/temperature curve such that it may be adjusted to parallel or closely approximate the pressure/temperature of a known, commercial refrigerant needing to be replaced.

[0012] The refrigerant ofthe present invention is particularly suitable for the replacement of R-12, R-22 and R-502, with a non-ozone depleting alternative yet being directly substitutable into such system without need for retrofitting since the refrigerant may be modified to exhibit similar operating parameters ofthe refrigerant to be replaced. Likewise, the alternative refrigerant of the present invention may be substituted for R-134A with similar operating similarity however, the lubricant utilized in that system must be replaced with a mineral based oil which in the alternative refrigerant provides excellent miscibility and lubrication of a system requiring such.

[0013] The refrigerant of the present invention provides a more universal refrigerant than those presently used in automotive and portable systems and is compatible with large commercial systems, being able to be modified, such as during installation into a system, in its blend of ingredients to match the vapor pressure/temperature of a variety of refrigerants, thereby eliminating the need to inventory several different refrigerants or modified formulations thereof.

[0014] These and other advantages and objects ofthe present invention will become evident from the following description of preferred and alternative embodiments.

Brief Description of the Drawings

[0015] The present invention may be more fully understood with reference to the accompanying drawings in which:

FIG. 1 is a vapor pressure/temperature graph illustrating the performance of the invention in relation to R-12.

FIG. 2 is a vapor pressure/temperature graph illustrating the performance of an alternative embodiment of the invention in relation to R-134A.

FIG. 3 is a vapor pressure/temperature graph illustrating the performance of a further alternative embodiment of the invention in relation to R-12.

FIG. 4 is a vapor pressure/temperature graph illustrating the performance of a further alternative embodiment of the invention in relation to R-22.

FIG. 5 is a vapor pressure/temperature graph illustrating the performance of a further alternative embodiment of the invention in relation to R-22.

FIG. 6 is a vapor pressure/temperature graph illustrating the performance of a further alternative embodiment ofthe invention in relation to R-502.

Description of Preferred Embodiments

[0016] With the elimination of refrigerant R-12 from the market because of its detrimental environmental characteristics, it was important to reexamine hydrocarbons as a refrigerant. It is well known that propane in pure form is a very efficient refrigerant, as is butane. Likewise, ammonia has seen wide use as a refrigerant. It is also well known that a refrigerant must be safe to handle, transport, install and operate in the cooling or refrigeration system. Leakage of a system must be anticipated making nonflammable and nontoxic characteristics important factors for a system operating in a closed space.

wherein the ratios of constituents are blended such that the thermodynamic properties of the refrigerant approximate those of the refrigerant R-22. The composition of MT-31 for the substitution for R-22 is composed of about 73 % hexafluoropropylene (R-1216; about 23 % chlorodifluoromethane (R-22) and about 4 % propane (R-290). Figure 4 illustrates the pressure/temperature curve of this refrigerant identified as with the solid line and R-22 as a dashed line. It will be noted upon examining the curve that the profile extends from about -30° C. to about 100° C at pressures ranging from about 0 pounds per square inch to about 150 pounds per square inch. Further examination of the Figure 4 discloses that the MT-31 pressure/temperature profile closely parallels that for R-22.

[0025] Figure 5 illustrates the vapor pressure/temperature curve for the MT-31 alternative refrigerant embodiment further adjusted in its composition demonstrating the control over the upper one-half of the curve in order to "fine tune" the curve to closely approximate the vapor pressure/temperature curve of a refrigerant to be substituted for. By increasing the weight percent of R-1216 to about 80 % by weight, decreasing the R-22 to about 18 % and reducing the R-290 to about 2 % by weight, the upper end of the curve is modified such that it illustrates a generally lesser increase in pressure with a continuing increase in temperature where the variation of the vapor pressure/temperature curve of the composition of Figure 2 shows a general increase in pressure as temperature increases however, the knee of both curves occurs at the same approximate point.

[0026] Alternative embodiments of the invention, illustrating the use of other of the C1-C6 hydrocarbons in a blend to replace R-22 are: a blend of about 90 % by weight of R-1216, about 4 % by weight of R-22, about 2 % by weight of butane and about 4 % by weight of iso-butane; and a blend of about 84 % by weight of R-1216, about 10 % by weight of R-22, about 4 % by weight of butane and about 2 % by weight of iso-butane. These alternative embodiments exhibit vapor pressure/temperature curves very similar to the curves of M-31 on Figure 4.

[0027] It is this recognized capability to adjust the upper portions of the vapor pressure/temperature curves of the alternative refrigerant of the present invention which allows for the matching of its vapor pressure/temperature curve to that of a selected refrigerant which may exhibit lesser favorable properties such as flammability, toxicity and corrosiveness.

[0028] The stability of the nonflammability of the alternative refrigerant of the present invention was examined by gradually venting off 60 % (weight percent) of the composition from a system. During the venting, with the system temperature maintained at about 25 ° C., the vapor pressure of the blend of components varied less than 7 % from the initial value. This verified the stability of the refrigerant as nonflammable during the venting since the ratios of components (by weight percent) were essentially constant. The characteristic of nonflammability of the present invention is thought to be due to the close match of boiling point of R-22 and R-290, both included in substantially lesser amounts than the R-1216, but in approximately equal quantities to each other such that they remain in a generally constant ration (in a particular embodiment blend) if evaporated off due to a leak. Likewise, since they are minority constituents of the particular blend embodiment, the vapor pressure/temperature curve of the embodiment varies only slightly as their concentration varies (diminishes) from that of R-1216, which remains generally unchanged. This characteristic also assures that the thermodynamic performance (including efficiency) remains relatively constant during evaporation of the refrigerant. These characteristics indicate that the alternative refrigerant of the present invention is a safe and efficacious replacement for the R-12, R-134A, R-22 and R-502 systems having to be recharged with an alternative to the original refrigerant.

[0029] Additional advantages of the present invention were discovered under the testing of the use of the refrigerant in a system. It is well recognized in the field of refrigeration that the temperature of the suction (low side) and the discharge (high side) of the refrigeration compressor is critical to the efficiency (capacity) of the system. The refrigerant of the present invention, when charged into a system designated to use any of R-12, R-134A, R-22 and R-502 reduces the suction (low side) temperature of the compressor 10 % or more and reduces the discharge (high side) 15 % or more. Those familiar with the principles of refrigeration will recognize that the reduction of suction and discharge temperatures reflects the greater compressibility of the refrigerant of the present invention. Reduction of these temperatures illustrates the lesser amount of energy necessary to operate the cooling cycle and the gain in efficiency/capacity. Therefore, not only is a refrigerant provided that is ultimately less toxic and degrading to the environment, but also provides improved operating parameters for the system.

[0030] As is recognized, the above described alternative refrigerants to R-12 and R-22 include hexafluoropropylene (R-1216) as the primary component. As described above, R-22 is added to the hexafluoropropylene to improve the exhibited thermodynamic capacity of the refrigerant and to cause its temperature/pressure curve to closely match those of R-12 and R-22, such that the alternative refrigerant will perform in the selected system in a manner consistent to the refrigerant replaced. Likewise, a hydrocarbon is incorporated to aid in the improvement of the overall thermodynamic performance. Both the R-22 (chlorodifluoromethane) and the hydrocarbon have drawbacks to long term refrigerant usage. R-22 is not as environmentally friendly as numerous other refrigerants available and is scheduled for a ban in 2010 by the U. S. Environmental Protection Agency. At that time, all compounds incorporating any amount of the component will have to be withdrawn from the market. As related above, hydrocarbons are known flammable substances. While in the present usages they are incorporated in small percentages and form a near aziotropic compound

(continued)

R-502 Substitute					
Octafluoropropane		10	30		40
hydrocarbon	2	2	10	40	

[0033] Likewise, it is well known in the refrigeration art that the discharge pressure of the refrigerant into the coils impacts the temperature of the refrigerant entering the condenser. Excessive temperature must be reduced which manifests a greater portion of the coils of the condenser for reduction of the temperature and lesser portions for the desired system cooling thereby dramatically lowering both the efficiency and the capacity of the system. Reduction of the high side refrigerant temperature reduces the amount of condenser dedicated to cooling the refrigerant and allowing more of the condenser to impact the cooling of the media (air in an air conditioner). The disclosed alternative refrigerants improve performance of the same systems when charged with R-12, R-134A, -22 and R-502.

Claims

1. A non-inflammable refrigerant composition for use in substitution of a chlorofluorocarbon refrigerant and whose vapor pressure/temperature curve may be varied by adjusting the mixture of the ingredients thereof to approximate the vapor pressure/temperature curve of at least one chlorofluorocarbon, consisting essentially of:

   i) one or more hydrocarbons selected from the group consisting of methane, ethane, propane, butane, isobutane, hexane and ethylene in an amount from 1% to 10% by weight;
   ii) a fluorinated alkane in an amount from 5% to 65% by weight; and
   iii) the balance of hexafluoropropylene.

2. A non-inflammable refrigerant composition for use as a substitute for the refrigerant R-502 and which consists essentially of:

   i) hexafluoropropylene in an amount from 30% to 60% by weight;
   ii) a fluorinated alkane in an amount from 10% to 60% by weight;
   iii) a hydrocarbon in an amount from 0% to 10% by weight.

3. The non-inflammable refrigerant composition according to Claim 2 wherein the composition additionally includes chlorodifluoromethane in an amount from 30% to 60%.

4. The non-inflammable refrigerant composition for use as a substitute for the refrigerant R-12 or R-134A and consisting essentially of:

   i) hexafluoropropylene in an amount from 75% to 95% by weight;
   ii) a fluorinated alkane in an amount from 5% to 25% by weight;
   iii) a hydrocarbon in an amount from 0% to 10% by weight,

   or as a substitute for the refrigerant R-22 and consisting essentially of:

   i) hexafluoropropylene in a n amount from 40% to 75% by weight;
   ii) a fluorinated alkane in an mount from 5% to 60% by weight;
   iii) a hydrocarbon in an mount from 0% to 10% by weight.

5. The non-inflammable refrigerant composition according to any one of claims 1 to 4, wherein the fluorinated alkane is selected from decafluorobutane and octafluoropropane.

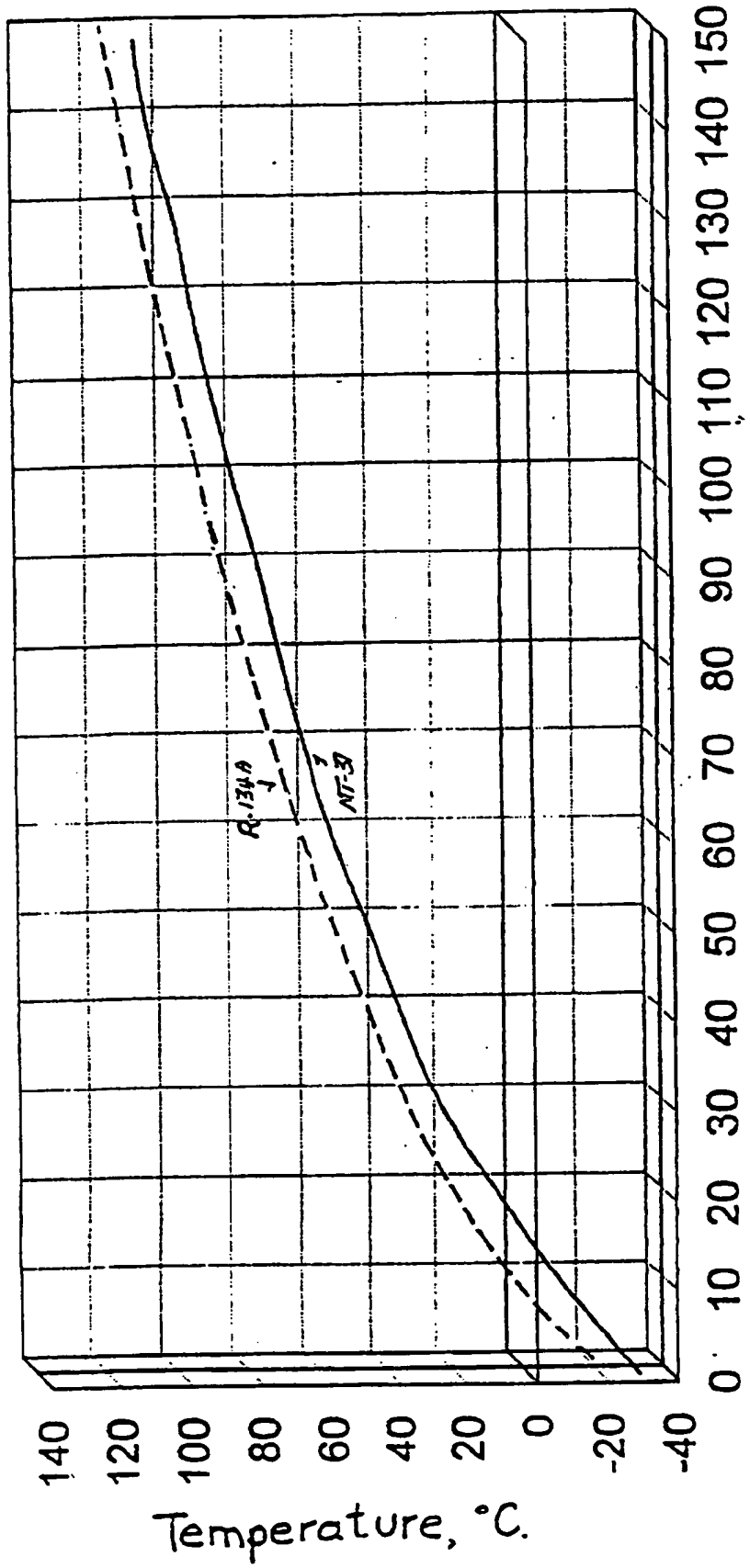
Pressure, p.s.i.
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
Temperature, °C.
140
120
100
80
60
40
20
0
-20
-40
R-134a
AT-30

Fig. 2

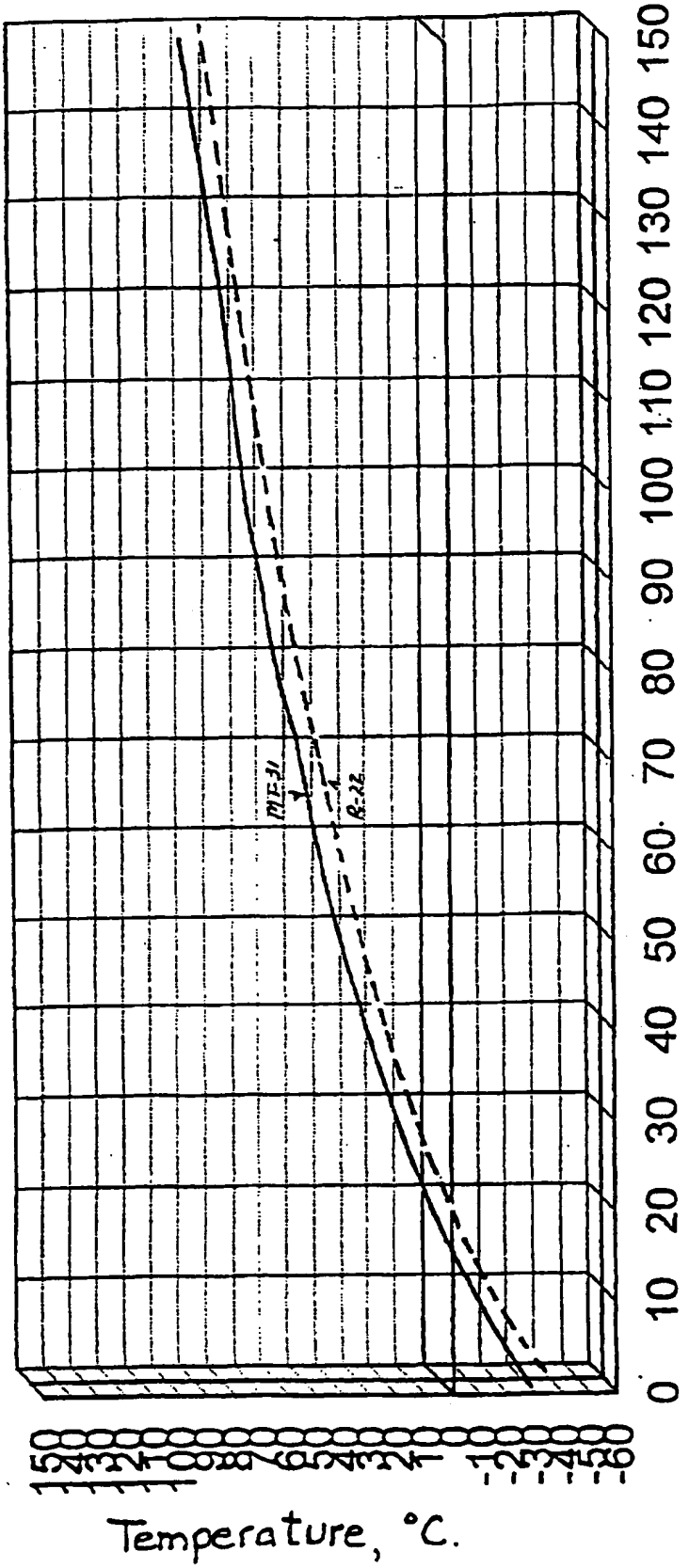
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
Pressure, p.s.i.
R-12
15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50
Temperature, °C.

Fig. 4

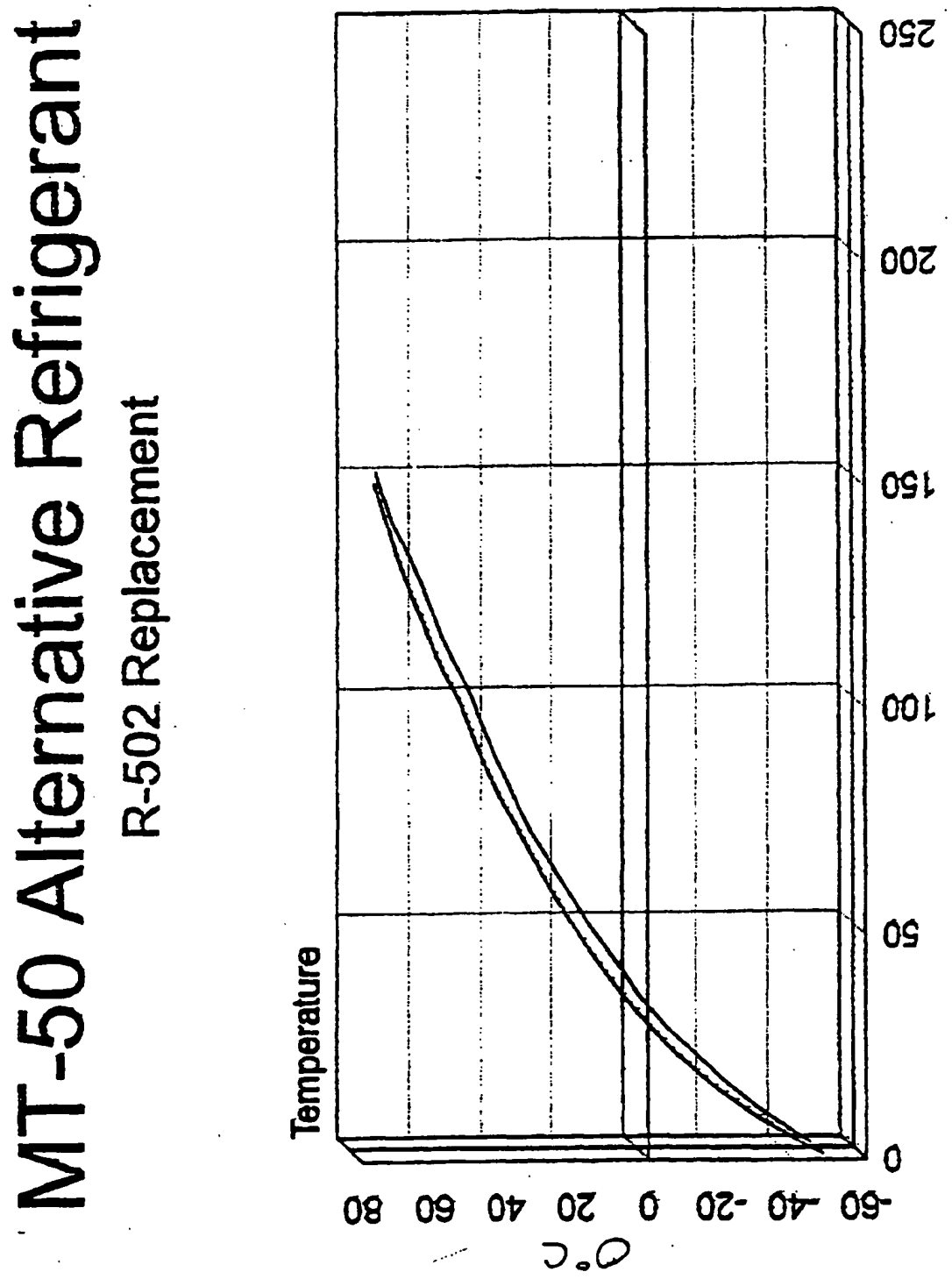
MT-50 Alternative Refrigerant
R-502 Replacement
Temperature
°C
-60 -40 -20 0 20 40 60 80
Pressure, p.s.i.
0 50 100 150 200 250

FIGURE 6